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ABSTRACT

The study described in this paper produced a comprehensive model for the design of micro- or minicomputer systems containing concepts and practices that educational administrators can use for the successful design of school district computer systems. This report focuses on the methodology used to build the model, which included the following phases: (1) review of relevant literature; (2) field research consisting of a survey of 100 school districts with outstanding administrative or instructional computer systems; (3) data analysis; (4) model development; and (5) model evaluation. The analysis of data patterns using a quadrant matrix is described and illustrated in detail, and procedures used to refine the preliminary set of design criteria and to develop the model are summarized. The basic elements of the model are then briefly reviewed and the two major sections of the model are considered--strategic planning activities, which focus on computer system inputs, and tactical planning activities, which focus on system processes, output, and feedback. (MES)

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DEVELOPING A COMPREHENSIVE MODEL FOR DESIGNING COMPUTER SYSTEMS IN SCHOOL DISTRICTS

by

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DEVELOPING A COMPREHENSIVE MODEL FOR DESIGNING COMPUTER SYSTEMS IN SCHOOL DISTRICTS

OBJECTIVES

The purpose of the study to be described in this paper was to create a comprehensive model containing concepts and practices that educational administrators can use to guide the planning and implementation of micro or mini computer systems in their school districts. The paper will concentrate on the methodology used to build the model and will briefly review the basic elements of the model.

The study focused on the design of micro and mini computer systems, rather that mainframe systems. Also, this research was limited to in-house computer systems, as opposed to services purchased from educational computing consortia. The study's model can be used to guide the design of administrative or instructional computer systems.

RESULTS OF THE STUDY

The study produced a comprehensive model for the design of micro or mini computer system in school districts containing concepts and practices cited in the literature and confirmed by the research populations as necessary or useful for the successful design of school district computer systems. The practices are often illustrated by techniques submitted by survey respondents. The specific nature of such a model could have taken many forms; however, an input-process-output model was chosen because it promised to help make the model understandable to practitioners. The model is divided into two major sections: (1) strategic planning activities, focusing on computer system inputs and (2) tactical planning activities, discussing computer system processes, outputs, and feedback.

EDUCATIONAL IMPORTANCE OF THE STUDY

This study has significance for both theory and practice in educational administration.

Theoretical Significance

The study goes beyond previous research in both form and function. It investigated ways in which school districts can best select and implement the newest electronic technologies -- microcomputers and minicomputers. The model can be used to design computer systems for both administrative and in-

structional applications because its scope is not limited to specific data processing applications or selected aspects of computer system design. Rather, this study's end-product is a model that is comprehensive in nature: It considers the various phases of the design process and the systems within a school district that may be affected by a new or improved computer system. The study used nation-wide research populations; this methodology made the results generalizable, and therefore useful, to a wide variety of school districts.

Practical Significance

A comprehensive conceptual and operational model for designing computer systems in school districts may help educators in the field cope with what must sometimes appear to be irrational and chaotic inputs. There are many factors that can make the design process very confusing: rapid advances in the field of computer technology, vendors eager to make a sale, advice from too many sources, and countless brands of hardware and software. Because this study's model makes the process of computer system selection and implementation more orderly and systematic, the model can guide school administrators in carrying out appropriate school district activities for adaptation and growth in response to the new technologies. Since this research incorporates information about the actual design experiences of school districts, educational administrators can use the model to avoid initial mistakes and trial-and-error methods that cost time and money. A more efficient and effective design process can then lead to better use of the resources allocated to computer system development.

THEORETICAL FRAMEWORK

General systems theory as presented by Immegart and Pilecki (1973) was used in three ways in the study:

1. To explain the phenomenon known as the Computer Revolution, schools' reactions to it, and the need for a study of this kind;

2. To guide model development by aiding the researcher's consideration of any and all concepts that are necessary for healthy systems (i.e., computer systems);

3. To organize the many concepts and practices contained in the model into a logical order and a preferred action sequence. An input-process-output model was used for this purpose.

RESEARCH METHODOLOGY

The research methodology had five phases: (1) a review of the relevant literature; (2) field research; (3) data analysis; (4) model development; and (5) model evaluation.

Review of the Relevant Literature

The purpose of the literature review was to gather information on all topics which could be included in a macroscopic model for computer system design. Because there were no holistic models of this nature in the literature, a wide search was necessary. Investigated were change theory, computer system design, education, electronic technology, ergonomics, general systems theory, management information systems, networking and telecommunications, and planning. The result was a preliminary set of design criteria that provided a skeleton and a starting point for the study's model. Systems theory in general and an input-process-output (IPO) model as described by Ashby (cited in Bertalanffy, 1968) provided a suitable framework for organizing the design criteria. An IPO model was used because it is an uncomplicated and universally applicable model that can simplify the study of a system with an extensive number of interrelated parts, such as a computer system (Immegart & Pilecki, 1973, p. 80). Furthermore, presenting concepts and practices in the logical order of inputs, followed by processes, outputs, and feedback, corresponded to the sequential order of computer system design activities recommended in the literature. This preliminary set of design criteria was then refined by the results of the field research.

Field Research

The field research consisted of a survey of selected school districts and telephone interviews with computer system designers/managers of districts chosen from the survey populations. The purpose of the field research was to determine which concepts and practices contained in the preliminary set of design criteria were actually being used by practitioners to design in-house computer systems.

Nomination Process

For this study, it was important to include only those school districts that had designed efficient and effective computer systems; it would not have furthered model development to include input from those school districts that had done a poor job of designing their computer systems. Therefore, a nomination process was used to gather a pool of appropriate school districts.

Nominators from across the nation were asked to submit names of school districts considered outstanding in the design or use of their computer systems as per a set of nominating criteria. The nominator population consisted of the researcher's dissertation committee, the study's panel of experts (a group of eight individuals in New York State who were knowledgeable about education and computers), individuals suggested by the dissertation committee and the panel of experts, state presidents of the Association of Educational Data Systems (AEDS), selected state presidents and executive directors of the Association of School Business Officials (ASBO), and names culled from the literature. Seventy-two nominators from twenty-six states across the nation responded to the request for names of school districts; this was 60.5% of those contacted. This resulted in 75 school districts nominated for their outstanding administrative computer systems (the administrative population for the survey) and 50 school districts nominated for their outstanding instructional computer systems (the instructional population for the survey).

Survey Process

A survey was then used to help refine the preliminary set of design criteria. The nominated school districts were sent questionnaires to determine which design concepts and practices they had found useful. One hundred school districts across the nation -- 80% of those contacted -- responded to the survey. All geographic areas of the country were represented.

The content of the questionnaire was based upon the preliminary set of design criteria extracted from the literature. The survey instrument contained three kinds of questions:

1. **Positively-worded statements with yes/no responses** (close-ended). Respondents were presented with a concept or practice whose use during computer system design was recommended by the literature. Respondents indicated "yes" for use or "no" for non-use of that item. The majority of questions were of this nature;

2. **Mutually exclusive check list questions** (close-ended). Respondents were presented with a number of mutually exclusive options and then were instructed to choose one;

3. **Open-ended questions.** Respondents were presented with a question to which a written, narrative reply was appropriate.

All close-ended questions contained two scales. All but two questions had an "actual" and a "hindsight" scale. Using the "actual" scale, respondents answered the questions as they pertained to the process of computer design as it actually occurred in their school districts. With the "hindsight" scale, respondents drew upon their design experiences to answer the questions as they pertained to the process of computer system design if it were to be done over in their districts. For two questions, use of a "present" and a "future" scale was more logical.

The purpose of having two scales was to aid model development. The degree of congruence between responses on the two scales gave a clearer picture of respondents' endorsement of that concept or practice as opposed to using only one scale.

The questionnaire contained four sections:

1. **General concepts and practices.** These questions dealt with the following design issues: planning, development of specifications, standardization of materials, user training, user support, systematic implementation, system security, centralization of functions, and evaluation and planned change;

2. **Specific computer system design practices.** This section sought information on the electronic arrangement of the hardware in the computer system and on who performs equipment maintenance and repair for the computer system;

3. **Situation-specific questions.** These were optional questions for survey respondents, to be answered only if the topics were applicable to the design of their computer systems. The questions focused on planning committee membership, service contracts, and use of parallel runs;

4. **Open-ended questions.** This section contained four open-ended questions whose topics were: (1) steps taken by the district to foster user acceptance of the computer system; (2) significant anticipated changes to the present computer system; (3) types of written documents that exist to guide users of the computer system; and (4) key advice to those who will design computer systems.

Interview Process

Twenty-four survey respondents were interviewed by telephone. The purpose of these interviews was three-fold: (1) to augment knowledge of promising concepts and practices

identified in the literature and the survey; (2) to obtain clarification of issues not resolved by survey results; and (3) to enrich model development by obtaining from computer system designers recommendations that were more insightful than those that could be given on a questionnaire.

Data Analysis: The Data Analysis Paradigm

The Data Analysis Paradigm was the first step in building a comprehensive model for the design of computer systems in school districts. The results of these analyses were used in the Model Development Paradigm to help construct the study's model. The Data Analysis Paradigm consisted of two parts: determining data merger and forming data patterns.

Part 1: Determining Data Merger

The purpose of Part 1 was to determine for which survey questions administrative population data and instructional population data could be merged and for which questions data from the two populations should remain segregated. This had implications for both the next part of data analysis and for model development. Responses from the administrative population were compared with responses from the instructional population, controlling for scale. Thus, for data from each survey question, two comparisons were made:

1. "Actual" scale: Administrative population responses vs. instructional population responses;

2. "Hindsight" scale: Administrative population responses vs. instructional population responses.

If, for both scales, no statistical significance was found, responses from the two populations were merged for that question because respondents' answers were independent of their population; there was no association between a respondent's population and his or her answer to the question. If statistical significance existed for the population comparisons in either the "actual" or the "hindsight" scale, data from the two populations were not merged for that question. A chi-square test was used to determine the presence or absence of statistical significance, and an alpha level of 0.01 was used to avoid Type I errors.

Part 2: Forming Data Patterns

The second Part of the Data Analysis Paradigm was to determine if, for each survey question, there was a difference between what respondents actually did during the design process ("actual" scale) and what they would have done if

they were to repeat their design experiences ("hindsight" scale) -- and the nature of that difference. This was done for each question by forming data patterns from the responses on both scales. These data patterns became the basis of the Model Development Paradigm.

The scale comparisons took one of two forms, depending on whether data from the two populations were merged or segregated:

1. **If no statistical significance was found between population responses,** "actual" scale responses were compared with "hindsight" scale responses for all respondents (that is, responses from the administrative population merged with responses from the instructional population);

...or...

2. **If statistical significance was found between population responses:**

   a. "Actual" scale responses were compared with "hindsight" scale responses for the administrative population alone;

   ...and...

   b. "Actual" scale responses were compared with "hindsight" scale responses for the instructional population alone.

Because each close-ended question had two scales, the range of possible responses could be depicted in matrix form, with the number of cells determined by the number of possible response choices for each scale. To form data patterns, frequencies and percentages of response frequencies were calculated for each cell of the matrix of each question as follows:

1. **For each positively worded statement with a yes/no response choice,** data were analyzed in a 2 x 2 matrix format;

2. **For each mutually exclusive check list question,** data were analyzed in an N x N matrix format, with the number of response choices determining the value of N.

The two survey questions with "present" and "future" scales were treated the same as questions with "actual" and "hindsight" scales.

Model Development: The Model Development Paradigm

There were two ways in which the Model Development Paradigm used the results of data analysis to develop the study's model:

1. **Generalization of findings.** To indicate which survey and interview findings were applicable to school district computer systems in general and which findings were applicable to only administrative computer systems or instructional computer systems;

2. **Refinement of the preliminary set of design criteria.** To indicate which concepts and practices in the preliminary set of design criteria should be retained in the study's model, which should be eliminated, and which should undergo further investigation.

The following is an elaboration of these two model development concepts.

Part 1: Generalization of Findings

The first part of the Data Analysis Paradigm was to compare, for each survey question, administration population responses to instructional population responses. The results of this analysis were used in the Model Development Paradigm to determine whether concepts and practices were generally applicable or pertained to a particular type of computer system. For questions where no statistically significant difference was found between the two populations, the corresponding concept or practice was discussed in terms of its applicability to all types of computer systems, regardless of function. Where data analysis revealed a statistically significant difference between responses from the two populations, discussion was separated into relevance of the concept or practice for administrative computer systems or for instructional computer systems. This particular facet of the Model Development Paradigm helped make the study's model both universal in nature and system-specific, thereby increasing its potential utility.

Part 2: Refinement of the Preliminary Set of Design Criteria

One purpose of the field investigations was to use the experience of practitioners, i.e., survey respondents, to refine the preliminary set of design criteria. Questionnaire items were based upon concepts and practices suitable for inclusion in the process of computer system design as suggested by the literature. Where practitioners recommended the use of a particular concept or practice, thus agreeing

with the literature, that concept or practice was retained in the study's model. There were some instances, however, where the practitioners did not recommend use of a concept or practice and did not agree with the literature; those concepts and practices were eliminated from the comprehensive model. The researcher relied more heavily on practitioners' viewpoints, because data from surveys and interviews were the result of actual hands-on experience with computer system design, rather than speculation or theory, which may or may not have been field-tested.

The second part of the Model Development Paradigm is based upon the assumption that each item has two scales, "actual" and "hindsight" and two mutually exclusive responses. The second task of the Data Analysis Paradigm was to compare, for each survey question, "actual" scale responses to "hindsight" scale responses. The results of this data analysis yielded percentages of responses in each of four quadrants as depicted in the Quadrant Matrix, Figure 1 below.

For each question, the distribution of frequencies in the quadrants resulted in one of five data patterns:

1. **Single quadrant data pattern.** The majority of response frequencies were in one quadrant, either Quadrant I, Quadrant II, Quadrant III, or Quadrant IV;

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes	**QUADRANT I** "Actual:" Yes "Hindsight:" Yes	**QUADRANT II** "Actual:" Yes "Hindsight:" No
no	**QUADRANT IV** "Actual:" No "Hindsight:" Yes	**QUADRANT III** "Actual:" No "Hindsight:" No

Figure 1. Quadrant Matrix

2. **Diagonal data pattern.** The majority of response frequencies were in two diagonal quadrants, either Quadrants I and III or Quadrants II and IV;

3. **Column data pattern.** The majority of response frequencies were in two quadrants in the same column, either Quadrants I and IV or Quadrants II and III;

4. **Row data pattern.** The majority of response frequencies were in two quadrants in the same row, either Quadrants I and II or Quadrants II and IV;

5. **No discernible pattern.**

The Model Development Paradigm consisted of a set of decision rules based on the above data patterns and the distribution of frequencies within those patterns. These decision rules helped determine the degree of endorsement by survey respondents of each concept or practice. The following describes the model development decisions corresponding to each data pattern.

Single quadrant data pattern. In this pattern, the majority of response frequencies -- at least 55% -- were in one quadrant, with small percentages of responses equally divided among two or more remaining quadrants.

Quadrant I data pattern ("actual" scale: yes; "hindsight" scale: yes). This data pattern indicated that respondents had actually used the concept or practice in designing their districts' computer systems and that they would use it again. In this case, practitioners fully agreed with the literature and very strongly endorsed the item. Therefore, the concept or practice was included in the study's model as necessary for the successful design of school district computer systems.

Quadrant II data pattern ("actual" scale: yes; "hindsight" scale: no). In this data pattern, respondents had used the concept or practice during the design process but had indicated that they would not use it again; they had found the concept or practice unsatisfactory. This represented a strong rejection of the item by respondents. If the majority of responses frequencies fell in Quadrant II, the corresponding item was excluded from the study's model or noted as counterproductive to the successful design of school district computer systems.

Quadrant III data pattern ("actual" scale: no; "hindsight" scale: no). In this data pattern, respondents indicated that they did not use the concept or practice, nor would they have used the concept or practice if they were to repeat their experiences. They felt that the concept or practice would not significantly improve the design process.

This was also a strong rejection of the item. Thus, if the majority of the responses fell in Quadrant III, the concept or practice was excluded from the study's model or noted as counterproductive to the successful design of school district computer systems.

Quadrant IV data pattern ("actual" scale: no; "hindsight" scale: yes). This data pattern indicated that, although respondents did not use the concept or practice, they would use it if they were to repeat their experiences; they felt that the item might improve the design process. However, the utility accorded the item in hindsight was based on speculation, rather than experience: Inclusion of that concept or practice in the design process may or may not actually improve the outcome. Therefore, a Quadrant IV data pattern represented tentative items for inclusion in the model which were investigated and researched further before a model development decision was made. Methods of investigation included analysis of data from open-ended survey questions, telephone interviews in selected school districts, and discussions with members of the panel of experts.

Figure 2 summarizes the model development decisions for the single quadrant data pattern.

Diagonal data pattern. In this pattern, the majority of response frequencies -- at least 75% -- were in two diagonal quadrants, either Quadrants I and III or Quadrants II and IV.

Quadrant I/Quadrant III diagonal data pattern. In this data pattern, the majority of response frequencies were in Quadrants I and III. However, the distribution of those frequencies between the two quadrants affected the model development decision. Three different configurations occurred:

1. There was a higher percentage of response frequencies in Quadrant I than in Quadrant III;

2. There was a higher percentage of response frequencies in Quadrant III than in Quadrant I;

3. Response frequencies were equally divided between the two quadrants.

A greater percentage of response frequencies in Quadrant I indicated a weak endorsement of the item. A large number of respondents (Quadrant I) found the item helpful; they used the concept or practice and would use it again if they were to repeat their design experiences. However, there was a substantial number of respondents (Quadrant III) who did not feel that the item was essential to the design process. Therefore, the concept or practice was included in the study's model as desirable, but not necessary, for the suc-

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes	QUADRANT I (yes/yes) Include the concept or practice in the study's model as necessary for the successful design of school district computer systems. (STRONGLY ENDORSED)	QUADRANT II (yes/no) Exclude the concept or practice from the study's model or note it as counterproductive to the successful design of school district computer systems. (STRONGLY REJECTED)
no	QUADRANT IV (no/yes) Investigate the concept or practice further before making a model development decision. (INCONCLUSIVE)	QUADRANT III (no/no) Exclude the concept or practice from the study's model or note it as counterproductive to the successful design of school district computer systems. (STRONGLY REJECTED)

Figure 2. Single Quadrant Data Pattern

cessful design of school district computer systems.

A greater percentage of response frequencies in Quadrant III indicated a weak rejection of the item. A large number of respondents (Quadrant III) did not endorse the item; they did not use the concept or practice, nor in hindsight would they have used it. However, there were some respondents (Quadrant I) who did use the concept or practice -- for whatever reason -- and liked it enough to indicate that they would use it again if they were to repeat their design experiences. Therefore, the concept or practice was noted in the study's model as unnecessary or undesirable under ideal circumstances for the successful design of school district computer systems; it could be included in the design

process if a strong rationale warranted its use.

An equal percentage of responses in Quadrants I and III indicated that the item was judged by the populations to be a non-critical issue. Many respondents (Quadrant I) used the concept or practice and would use it again; an almost equal number (Quadrant III) indicated the opposite. Thus, it appears that use or non-use of the item will not seriously affect the outcome of the design process. In this case, the item was included in the study's model as optional for the successful design of school district computer systems.

Quadrant II/Quadrant IV diagonal data pattern. In this data pattern, the majority of response frequencies were in Quadrants II and IV. The distribution of those frequencies between the two quadrants affected model development decisions. Three different configurations occurred:

1. There was a higher percentage of response frequencies in Quadrant II than in Quadrant IV;

2. There was a higher percentage of response frequencies in Quadrant IV than in Quadrant II;

3. Response frequencies were equally divided between the two quadrants.

A greater percentage of response frequencies in Quadrant II indicated a weak rejection of the item. A large number of respondents (Quadrant II) used the item, but found it unsatisfactory and would not use it again. There was also a substantial number of respondents (Quadrant IV) who did not use the item but felt it might enhance the design process; they indicated they would use it if they were to repeat their design experiences. However, Quadrant IV respondents based their "hindsight" scale answers on speculation; inclusion of the item may or may not improve the design process. In light of this information, the experience of those practitioners who had actually used the concept or practice guided the model development decision. It should be noted that this did not represent a strong rejection of the concept or practice because of the possibility that the item may be useful in certain situations. Thus, the concept or practice was noted in the study's model as unnecessary or undesirable under ideal circumstances for the successful design of school district computer systems; it could be included in the design process if a strong rationale warranted its use.

A greater percentage of response frequencies in Quadrant IV required further investigation before a model development decision could be made. A large number of respondents (Quadrant IV) did not use the item, but felt that its use would improve the design process. However, there were some respondents (Quadrant II) who did use the item and

found it unsatisfactory. The speculative recommendation of Quadrant IV respondents, coupled with the possibility that the item is not suitable for inclusion in the model, suggested the need for further investigation of the item before a model development decision could be made. Methods of investigation included those previously stated.

An equal percentage of responses in Quadrants II and IV also required further investigation of that concept or practice before a model development decision could be made. The reason for this was the same as stated above.

Figure 3 summarizes the model development decisions for the Diagonal Data Pattern.

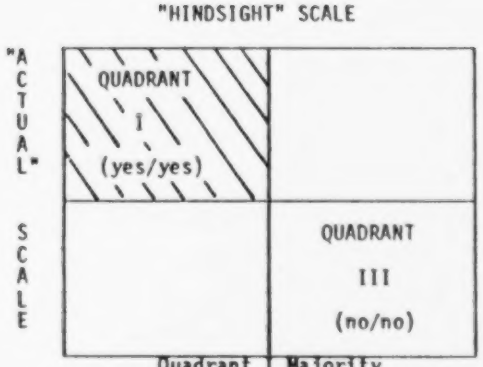
Column data pattern. In this data pattern, the majority of response frequencies -- at least 75% -- were in two quadrants in the same column, either Quadrants I and IV or Quadrants II and III. The distribution of response frequencies between two quadrants in the same column did not affect the model development decision.

Quadrant I/Quadrant IV column data pattern. This data pattern indicated a strong endorsement of the concept or practice. There were some respondents (Quadrant IV) who did not use the item, but felt it might improve the design process. They indicated that in hindsight they should have used the concept or practice, but this may be speculation. However, when this information is combined with the strong endorsement of the item by other respondents (Quadrant I), the decision favors the use of the concept or practice because the majority of all respondents -- both those that used the item and those that did not -- felt that it would be helpful to include the item in the design process. Therefore, these concepts and practices were included in the study's model as necessary for the successful design of school district computer systems.

Quadrant II/Quadrant III column data pattern. This data pattern indicated a strong rejection of the concept or practice. Both those respondents that used the item (Quadrant II) and those that did not (Quadrant III) did not endorse the concept or practice in hindsight. Therefore, those items were excluded from the study's model or noted as counterproductive to the successful design of school district computer systems.

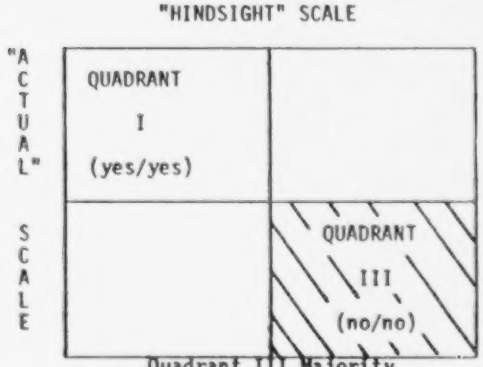
Figure 4 summarizes the model development decisions for the Column Data Pattern.

QUADRANT I/QUADRANT III DIAGONAL DATA PATTERN



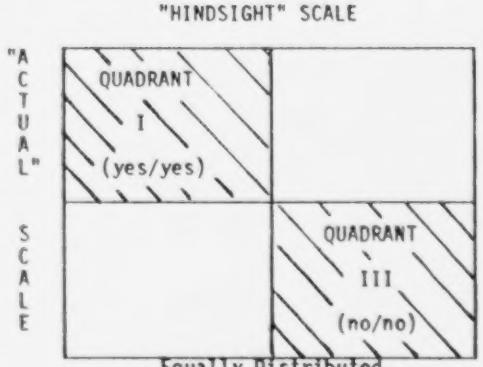
Quadrant I Majority

Include the concept or practice in the study's model as desirable, but not necessary, for the successful design of school district computer systems.



Quadrant III Majority

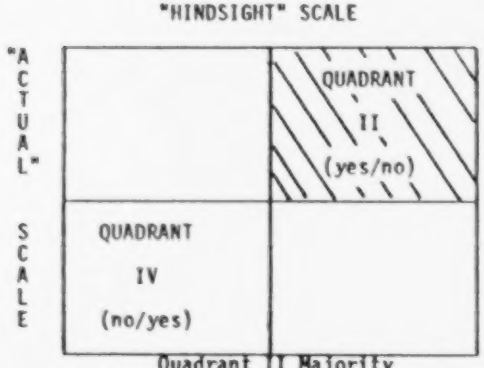
Note the concept or practice in the study's model as unnecessary or undesirable under ideal circumstances for the successful design of school district computer systems.



Equally Distributed

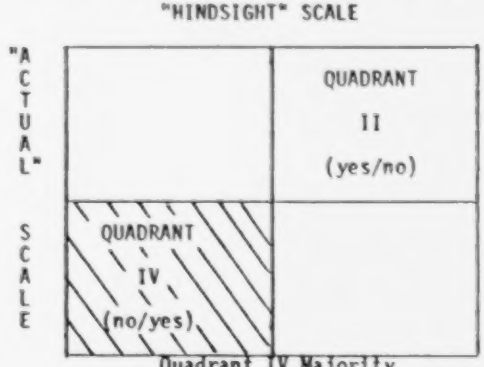
Include the concept or practice in the study's model as optional for the successful design of school district computer systems.

QUADRANT II/QUADRANT IV DIAGONAL DATA PATTERN



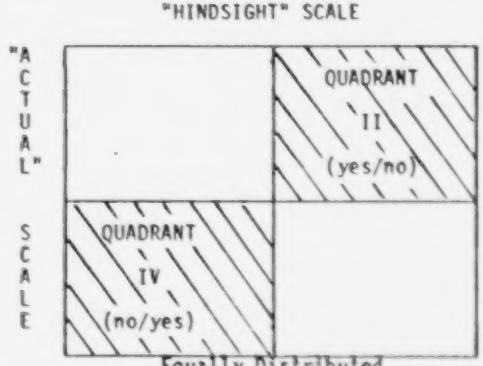
Quadrant II Majority

Note the concept or practice in the study's model as unnecessary or undesirable under ideal circumstances for the successful design of school district computer systems.



Quadrant IV Majority

Investigate the concept or practice further before making a model development decision.



Equally Distributed

Investigate the concept or practice further before making a model development decision.

Figure 3. Diagonal Data Pattern

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes	QUADRANT I (yes/yes)	
no	QUADRANT IV (no/yes)	

Quadrant I/Quadrant IV Column Data Pattern

Include the concept or practice in the study's model as necessary for the successful design of school district computer systems.

* * * * *

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes		QUADRANT II (yes/no)
no		QUADRANT III (no/no)

Quadrant II/Quadrant III Column Data Pattern

Exclude the concept or practice from the study's model or note it as counterproductive to the successful design of school district computer systems.

Figure 4. Column Data Pattern

Row data pattern. In this data pattern, the majority of response frequencies -- at least 75% -- were in two quadrants in the same row, either Quadrants I and IV or Quadrants II and III. The distribution of response frequencies between two quadrants in the same row did not affect the model development decision.

Quadrant I/Quadrant II row data pattern. This data pattern necessitated further investigation of the concept or practice before a model development decision could be made. In this configuration, the majority of respondents used the concept or practice. Some of them (Quadrant I) indicated they would use it again; others (Quadrant II) said they would not. Because of the differences of opinion, further investigation was needed. Investigation methods used were those previously stated.

Quadrant III/Quadrant IV row data pattern. This data pattern also required further investigation before a model development decision could be made. The majority of respondents did not use the concept or practice. In hindsight, some of them (Quadrant IV) would use it again and some (Quadrant III) would not. Therefore, further investigation of the concept or practice was needed, using methods previously stated.

Figure 5 summarizes the model development decisions resulting from the Row Data Pattern.

No discernible pattern. If there emerged no definite pattern of response frequencies among quadrants, further investigation of that concept or practice was necessary prior to making a model development decision. Methods of investigation included those previously stated.

Summary. Figure 6 summarizes the procedures used in the Model Development Paradigm to refine the preliminary set of design criteria and to develop the study's model.

The Model Development Paradigm was applied to close-ended survey questions with two scales, whose data could be placed in the two-by-two quadrant matrix. The Paradigm was altered slightly for mutually exclusive check list questions with N x N matrices. Part 1 of the Paradigm, Generalization of Findings, was applied to data from these questions to determine if they should be merged or segregated by population. For Part 2 of the Paradigm, Refinement of the Preliminary Criteria, cell percentages resulting from a comparison of "actual" and "hindsight" (or "present " and "future" scales) were interpreted without the benefit of a quadrant matrix and discussed in the study's model. The decision to retain or eliminate a concept or practice from the study's comprehensive model was guided by recommendations of practitioners.

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes	QUADRANT I (yes/yes)	QUADRANT II (yes/no)
no		

Quadrant I/Quadrant II Row Data Pattern

Investigate the concept or practice further before making a model development decision.

* * * * *

"HINDSIGHT" SCALE

"ACTUAL" SCALE	yes	no
yes		
no	QUADRANT IV (no/yes)	QUADRANT III (no/no)

Quadrant III/Quadrant IV Row Data Pattern

Investigate the concept or practice further before making a model development decision.

Figure 5. Row Data Pattern

DATA PATTERN	MODEL DEVELOPMENT DECISION
1. Single quadrant data pattern: a. Quadrant I 2. Column data pattern: a. Quadrant I/Quadrant IV	Include the concept or practice in the study's model as necessary for the successful design of school district computer systems. (STRONGLY ENDORSED)
1. Diagonal data pattern: a. Quadrant I/Quadrant III: majority in Quadrant I	Include the concept or practice in the study's model as desirable, but not necessary, for the successful design of school district computer systems. (WEAKLY ENDORSED)
1. Diagonal data pattern: a. Quadrant I/Quadrant III: equally distributed	Include the concept or practice in the study's model as optional for the successful design of school district computer systems. (JUDGED TO BE NON-CRITICAL)
1. Diagonal data pattern: a. Quadrant I/Quadrant III: majority in Quadrant III b. Quadrant II/Quadrant IV: majority in Quadrant II	Note the concept or practice in the study's model as unnecessary or undesirable under ideal circumstances for the successful design of school district computer systems. (WEAKLY REJECTED)
1. Single quadrant data pattern: a. Quadrant II b. Quadrant III 2. Column data pattern: a. Quadrant II/Quadrant III	Exclude the concept or practice from the study's model or note it as counter-productive to the successful design of school district computer systems. (STRONGLY REJECTED)
1. Single quadrant data pattern: a. Quadrant IV 2. Diagonal data pattern: a. Quadrant II/Quadrant IV: majority in Quadrant IV b. Quadrant II/Quadrant IV: equally distributed 3. Row data pattern: a. Quadrant I/Quadrant II b. Quadrant III/Quadrant IV 4. No discernible pattern.	Investigate the concept or practice further before making a model development decision. (INCONCLUSIVE)

Figure 6. The Model Development Paradigm

Use of Data from Open-ended Survey Questions and Telephone Interviews

The Data Analysis Paradigm and the Model Development Paradigm were not used on these data because of their subjective and unstructured nature. A unit record approach was employed to standardize answers as much as possible and to classify responses by category and population. Frequencies and percentages were calculated. The information gained from this analysis was used to refine the results of model development by adding new concepts and practices not contained in the preliminary set of design criteria, adding substance and detail with illustrative techniques, and providing clarification by resolving discrepancies that arose during model development.

Model Evaluation

Draft versions of the model were critiqued by the dissertation committee and the panel or experts, who evaluated the model to determine if it was complete, realistic, understandable, flexible, and useful. Evaluation results indicated that the model satisfactorily met all of the model criteria set forth and that it has potential utility for application in school districts.

THE COMPUTER SYSTEM DESIGN MODEL

The study's model is an action guide containing concepts and practices cited in the literature and confirmed by the research populations as necessary or useful for the successful design of school district computer systems. Practices are often illustrated by specific techniques and forms and exhibits submitted by survey respondents. The specific nature of the model could have taken many forms; however, an input-process-output model was chosen because it provided a framework for organizing the various ideas presented in the model into a logical order and a preferred action sequence. The model is divided into two major sections: (1) strategic planning activities, focusing on computer system inputs; and (2) tactical planning activities, discussing computer system processes, outputs, and feedback. A summary of the model follows.

Part I: Strategic Planning Activities

1. Plan for the Computer System: Choose Purposes and Parts

To guide the entire design process, strategic plans should be developed first. These plans should use a system's approach and be macroscopic in nature. Next, a feasibility

study should be conducted to identify the computing needs of the school district and to propose ways to meet these needs. A planning committee should be established, representative of the potential users of a computer system. This committee can then undertake preliminary planning activities, such as committee and meeting organization, securing top management support, providing training of committee members, and writing assumptions and philosophies to direct their future planning efforts. The committee should then assess data needs. This can be done through written surveys of and/or interviews with potential users, examination of existing systems and documents, and discussion by committee members. Based on these needs -- and the assumptions and philosophies determined earlier -- goals and objectives for a computer system can be developed. These will guide specification of required attributes for the selection of material inputs to the computer system, i.e., software, hardware, peripherals, and supplies. The selection criteria should be future-oriented to allow for the growth of the system. Before writing the specifications, however, it is necessary to first determine the desired electronic configuration for the computer system: stand-alone units, local area network, distributed data processing, or remote area data processing. The degree of standardization of the material inputs should also be established. Only then can specific selection criteria be developed for software, then for hardware and peripherals, and finally for vendors.

The committee should next investigate offerings in the marketplace. This can be done through requests for proposals, reference checks, product observation, and trial use. Selections can be made of first software, and then hardware, peripherals, and last vendors. Once selection of material inputs has been made, a computer system budget can be developed, including both investment and recurring costs. It is also appropriate at this time for the committee to investigate sources of funds to finance acquisition of a computer system.

The feasibility study is completed when the planning committee presents its findings to the superintendent, and if appropriate, to the board of education. The committee's report typically makes one of three recommendations: (1) termination of the project; (2) further investigation and study; or (3) acquisition and implementation of a computer system. If the planning committee recommends the last option, and the superintendent and the board approve, the committee can proceed with tactical planning activities.

Part II: Tactical Planning Activities

1. Design a Logical Structure for the Computer System: Establish Organization

The first step in achieving a logical structure for the computer system is to create a comprehensive and integrated system by identifying and then ordering into subsystems all possible components or functions of the computer system. Then, it is necessary to internally integrate those subsystems within the computer system so that they work in harmony with each other. It is also important to externally integrate the computer system with other departments of the school district to maximize the benefits of the computer system to the district and to minimize disruptions to daily activities.

Next, support and management functions should be centralized; these can include equipment maintenance and repair, purchasing, user training and support, and management and overall system coordination. The latter can be accomplished by designating a computer system coordinator who can facilitate computer system organization, implementation, and operation.

Facilities to house the computer system should then be selected and prepared. In doing this, it is important to pay attention not only to the operating requirements of the computer equipment, but also to the ergonomic (human comfort) needs of the users. It is also appropriate at this time to provide for a system of user support to aid users and to help solve their computing problems. This can be accomplished through a variety of means, including in-house peer support groups, regional user groups, regular school district computing newsletter, and vendor support.

2. Design Effective Processes for the Computer System: Determine Outputs and Deal with Constraints

The first step in achieving effectiveness is to determine the nature and appearance of computer system outputs. These outputs should be designed to meet the computing needs of the district and to reflect the goals and objectives established earlier in the planning process. Following output design, the nature and appearance of data inputs can be developed that will produce the desired outputs.

It is also necessary at this stage to determine possible constraints to computer system effectiveness and to move to obviate them. These constraints can include: physical and electronic security of the system; software piracy; data inputs that are relevant, timely, accurate, and reliable; and equal access to computers for users, especially in terms of

sex equity for student users of instructional computer systems.

3. Design Efficient Processes for the Computer System: Implement the Computer System

An implementation plan for the computer system should be developed which includes a timetable for implementation activities and provides for initial orientation sessions to introduce the new computer system to users and to the school district community. To promote efficiency, user manuals and user training should be provided prior to computer system implementation. The user manuals should include not only technical documentation for operating hardware, software, and peripherals but also procedural documentation to aid users in performing daily operations. This latter type of documentation can include organization charts, job descriptions, statements of goals and objectives, calendars, training materials, written procedures, forms, lists of available software, and reference materials. User training should also be conducted. It is helpful prior to training to write plans outlining the intended audience for training, the purposes of training, the information to be taught, the times and locations of training, and the methods of instruction.

After the above procedures have been accomplished, the computer system can be operationalized. The computer system should be phased in gradually, computerizing one application at a time. Parallel runs of computerized applications should be conducted simultaneously with manual operations. Manual operations should be abandoned only after computerized applications are working satisfactorily.

4. Evaluate the Computer System: Provide for Feedback and Adaptation

Regular evaluation of the computer system is important to determine changes in its environment (the school district or the larger technical, political, or social environments) and to discover the presence of system stress or disorder. The efficiency of computer system operations can be examined though process evaluations using on-going logs of user problems, on-site observations, comparison of the computer system against other school districts' computer systems, and user surveys. The effectiveness of computer system outputs can be determined through product evaluations, such as examination of computer system outputs, measurement of student achievement, measurement of growth in student enrollment in computer classes, on-site visits to other school districts to compare computer system outputs, and questionnaires.

Evaluation results may indicate the need for minor adjustments to the computer system to prevent more serious problems. Some examples include equipment maintenance and repair, expanded use of an application, modification of documents in the user manual, and an update of the computing curriculum. However, evaluation results may also point to major changes to be made to the computer system to combat conditions of system stress and disorder. These can include upgrading existing hardware and/or adding new machines, increasing network capabilities, expanding applications and upgrading and/or adding software, and adding or upgrading peripherals.

To continue an iterative process of evaluation and planned, prescriptive action and to provide continuity for computer system growth and change, it is advisable to establish an on-going planning committee. As the computer system ages, the committee may find it necessary to repeat the entire design process to help ensure orderly and purposeful change to and growth of the computer system through time.

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